that already evidence various stages of this destructive action; and second, there is the question of how to design and construct pavements in the future that will be immune to it.

The paper suggests some practicable answers for both of the above questions, and I am sure further progress of this research will bear fruit in the form of additional assistance. It is hoped that this research may continue.

By way of digression from the paper, I should like to suggest to you that there might well be a third important phase of this problem that should be given some serious consideration at this particular time. What about one of the three previously mentioned contributing factors to our troubles, the truck? What should be the future course with reference to load limits and highway financing that will result in this factor's bearing its just share of the burden of extra cost it so obviously causes? I am not prepared, nor do I presume myself qualified, to suggest an answer to this question; but I do believe it merits, and is getting, some very serious thought on the part of our legislators and those upon whom they depend for enlightenment on such matters.

MUD PUMPING

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Our first experience with mud pumping in the LaPorte District was on U.S. 20 in Porter County. This is a forty-foot cement concrete pavement built in 1931 and carrying the heavy traffic from Chicago and the Calumet industrial region across the north part of the LaPorte District. Traffic counts show that as much as 30% of these vehicles are heavy trucks. Surface failure of a serious nature was first noticed on this road about three years ago, and "mud pumping" was observed immediately. The action of the heavy trucks on this slab, over certain types of unstable subgrade, causes a slight up-and-down movement each time a truck goes over it. This movement at first is very slight; but soon, under certain weather conditions, particularly when the subgrade has become saturated, there begins a pumping action that forces water and mud through the pavement cracks and joints onto the surface. The subgrade material thus removed from under the slab causes a void near the joints and cracks and eventually traffic breaks off sections of the slab of from four to ten feet in length. At this rate it would not have been long until complete disintegration of the pavement had taken place. In order to save as much of this surface as possible, we diverted

truck traffic from this route. Further observation seems to indicate that all this pumping action was thereby eliminated.

This truck traffic was rerouted over U. S. 12, which is a 20-foot cement concrete pavement eight years older than the pavement on U. S. 20. After several months, a short section of this road began to show signs of similar failure. Investigation revealed that this was due to the same cause and, further, that the subgrade soil was of the same general character as that underlying the pavement on U. S. 20 where the first failures occurred. This fact was later confirmed in a study of a soil map of Porter County. From this it would seem that the subgrade is a major factor to be considered in combating this source of pavement failure.

During the past year a careful check has been made on all the roads in our district subjected to this type of traffic in order to determine the prevalence of this condition. We found that practically all of U. S. 6, U. S. 41 near Morocco, a long section of the new dual-lane pavement on U. S. 30 from U. S. 41 to a point just east of Valparaiso, and a short section of U. S. 30 near Plymouth showed signs of pumping, although not to the point where pavement failure resulted. An experimental section of U. S. 30, located approximately one mile east of Schererville, which was constructed with a sand cushion under the slab in 1937, was found to be particularly free from this trouble. This was interesting, especially in the light of the facts that the subgrade soil was the same as that with which we had our most serious trouble and that this road carried the same type of traffic. Assuming from this that the sand cushion was the preserving factor, all new rigid-type pavements constructed in this district during the past season have been placed on a sand cushion. It is too early yet to say that this is definitely the answer to this problem, but we believe it is a positive step in the right direction as far as new construction is concerned.

DRAINAGE OF HIGHWAYS AND AIRPORTS

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The technique of land drainage has been practiced for hundreds of years. The first tile drains in this country were placed in 1835. Since that time, many advancements have been made in drainage knowledge, and special techniques have been developed for many different drainage applications.